Predicting Reasonable Broadband Costs

On Behalf of the Nebraska Rural Independent Companies

January 6, 2011

Project Scope and Resources

- Goal: Produce a statistical means to predict the loop cost of a high-capacity terrestrial broadband network using public variables
- Data Set: Labor, material and engineering costs to build 227 rural areas and 209 town areas in 15 states served by 63 ILECs
- Team Members:
  - Vantage Point Solutions (VPS) of Mitchell, SD
  - Consortia Consulting of Lincoln, NE
  - Rolka, Loube, Saltzer Associates of Harrisburg, PA
  - Stone Environmental of Montpelier, VT

Data Compilation

1. Associated each VPS engineering project with a geographic area. Used exchange boundaries, separated into "Town" and "Rural" areas.
2. Identified cost drivers obtainable through public sources:

Size	Plowing Difficulty	Obstacles	Work Interruptions
Area	Soils Texture	Road Intersections	Frozen Ground Days
Road Mileage	Bedrock %	Stream Crossings	Rain Frequency
Households	Wetlands %		

3. Associated and conformed GIS data to the VPS project, e.g. created variables that "matched" the project data.

GIS Data Translation

1. Selected GIS variables as proxies for VPS data:

VPS Data	GIS Data
Area of Project	Calculated Area
Locations Served	Households using “Centroid” Method
Mainline Route Miles	“Clipped” Road Miles

2. Adjusted GIS mileage data for
   - unpopulated areas and
   - certain types of roads (major divided highways, roads with special characteristics such as cul-de-sacs, access ramps, and traffic circles and thoroughfares including walkways and driveways.)
3. Tested the households variable for growth or decline in population since the 2000 census.

Data Validation

- Compared the VPS and GIS data to identify data points where a geographic error or mismatch seemed likely.
- Created quality control screens:

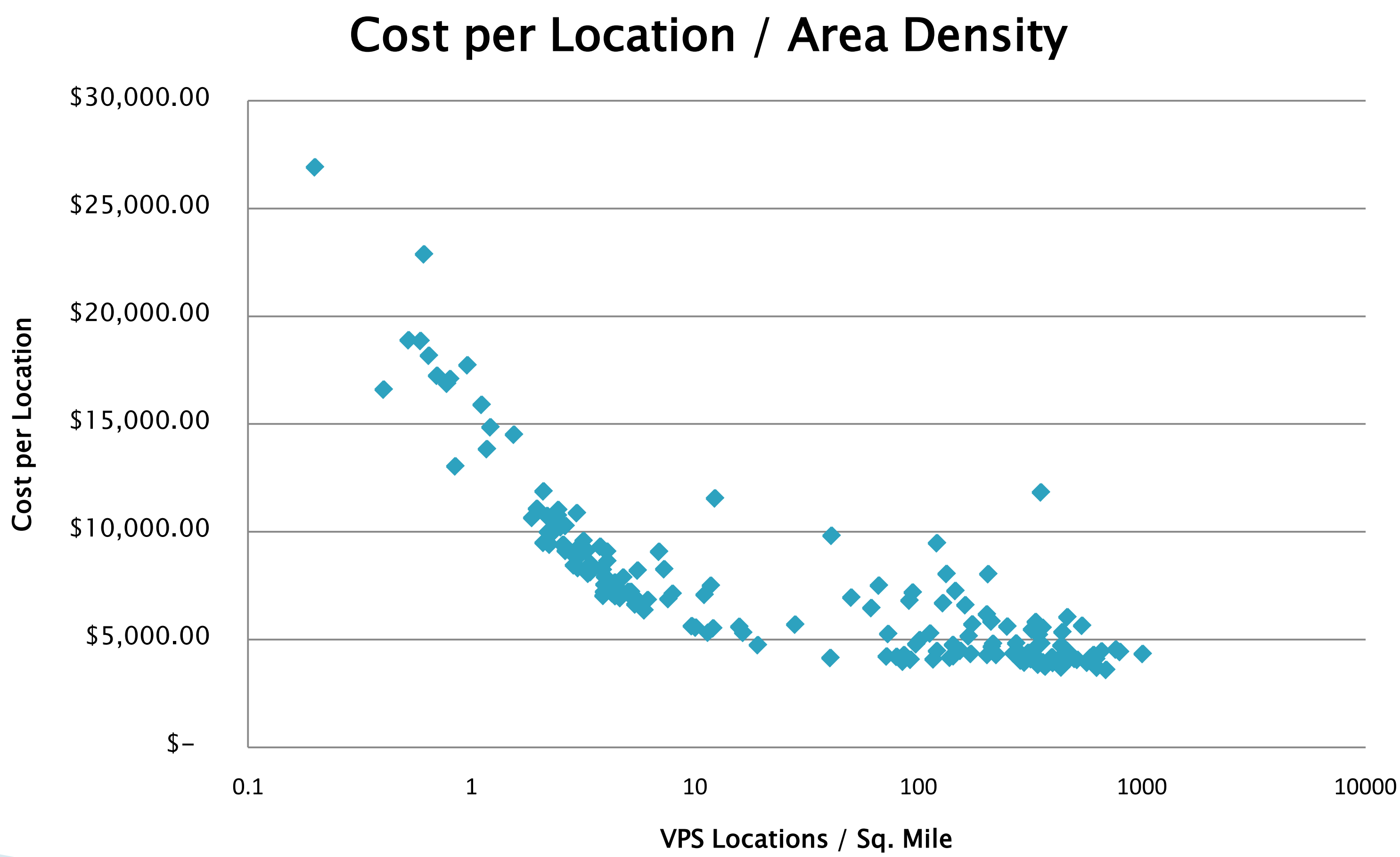
	Expected Value	Range of Acceptance	Data Points Accepted
GIS Area/Project Area	1	.9 to 1.1	391
Census HH/VPS Locations	.9	.7 to 1.1	297
GIS Road Miles/Route Miles	1	.8 to 1.2	258

- Records failing any of these screens were **not** used in regression. Excluded one other outlier with inconsistent GIS and VPS data.
- 167 records were used (85 rural and 82 town areas.)

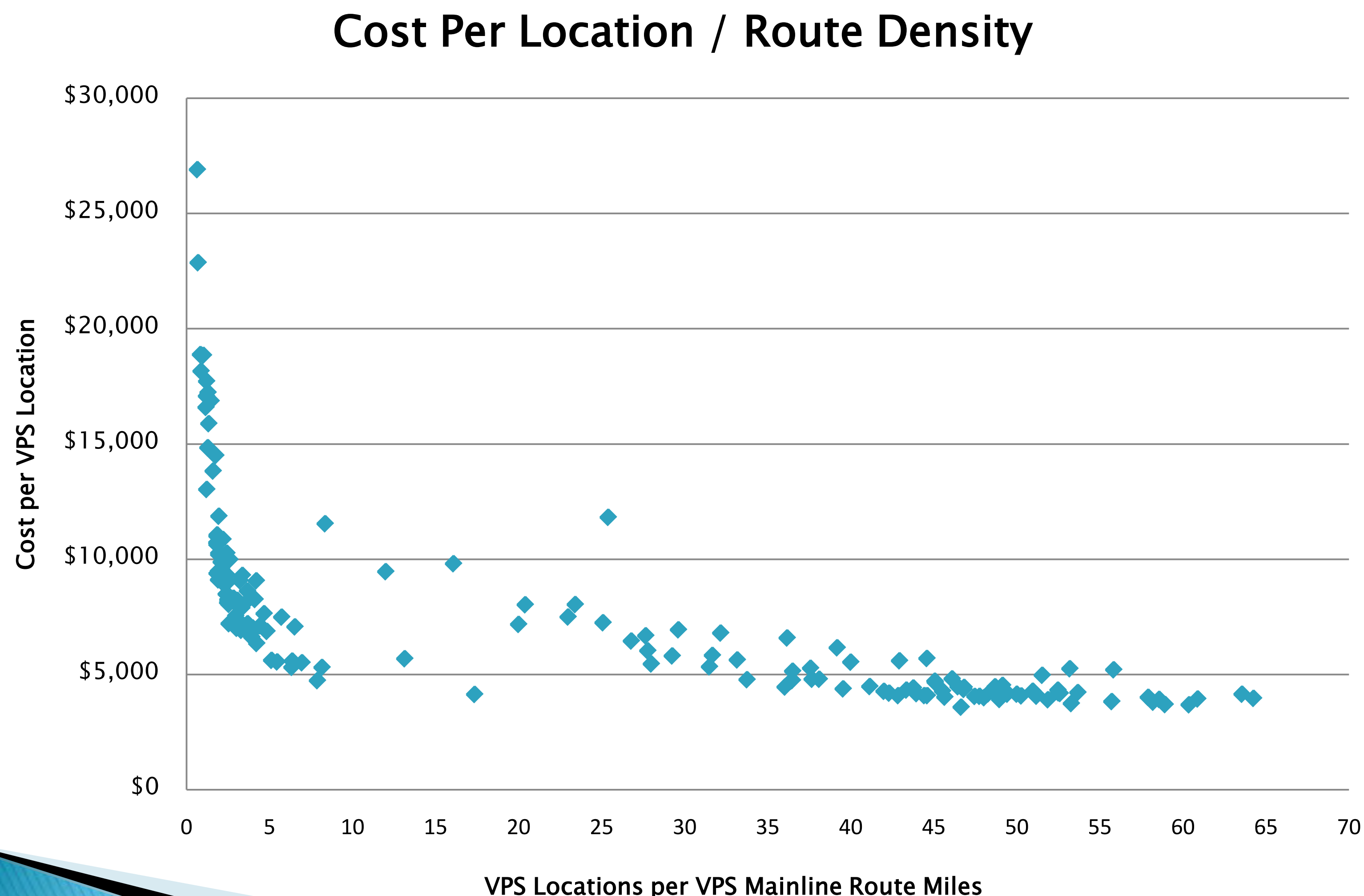
Regression Study

1. Updated engineering cost data to 2010 prices using the Consumer Price Index.
2. Determined that for VPS data, linear density (customers/route mile) was a better predictor than area density (customers/square mile).
   - Linear Density explained 87% of the variation in cost, whereas Area Density only explained 71%.
3. Verified that the R-squared did not degrade materially, 0.825 versus 0.87, when GIS data was substituted for the VPS.
   - Road miles instead of route miles.
   - Households instead of locations.
4. Evaluated using growth adjusted household data rather than raw census data from 2000. The R-squared didn't improve, thus used 2000 data.

Cost/Location by Customer Density



Cost/Location by Cable Route Mile



Regression Results

- Cost/Household = A + [B/(Households/Adjusted Road Miles)] + [C*Households] + [D*Frost Index] + [E*Wetlands %] + [F*Soils Texture] + [G*Road Intersections Frequency]

	Symbol	Coefficient	T-Statistic
Fixed Cost	A	$3,072	
Linear Density	B	$13,365	18.96
Households	C	-$0.8867	-2.10
Frost Index	D	$25.04	3.61
Wetlands %	E	$17,700	1.38
Soils Texture	F	$1,376	1.49
Road Intersection Frequency	G	$165.40	2.46

Conclusions

- *Linear density* is by far the most important predictor of construction cost, accounting for 82.5% of the variation in cost.
- The inclusion of other GIS variables improves the accuracy of the cost equation to 86.7%.
  - Weather interruptions, the number of obstacles and difficult soil types all add cost.
  - The number of households is negatively related to cost. Thus, larger projects cost less per customer and smaller projects cost more.
  - Inclusion of new variables or improvements in existing variables may increase the equation's accuracy, but probably not materially.

Cost Comparisons in the Data Set

- Average of <u>Total</u> Project Cost/Route Mile was Higher for Town than Rural.
  - Rural: $ 26,728 per mile
  - Town: $192,931 per mile
  - Town projects require more conduit, more frequent road crossings, more coordination with other utilities, and more customer drops.
- Because of lower customer densities in rural areas, the average cost <u>*per customer*</u> were higher.
  - Rural: $9,286 per customer
  - Town: $4,438 per customer
  - Rural customers require more mainline cable than town customers.
- Costs were unevenly distributed.
  - A substantial portion of the cost is incurred to serve a small number of customers.
  - In this data set, the three most expensive jobs, representing 1.7% of the projects, required 12% of the total investment.
- Outside plant comprised 58.5% percent of the total investment in the data set.

Possible Improvements

1. Including other engineering firms' data, especially from mountainous and coastal areas, would
   - create the opportunity to test existing results or
   - improve the regression equation.
2. Enhancing the "Soils Texture" variable.
   - Source of data used in regression: Soils Difficulty Table from the FCC's 1999 Synthesis Model.
   - These soil tables do not seem to reflect actual costs in rocky and clay soil areas.
   - An enhanced variable might increase the importance of the "Soils Texture" variable and change the importance of other variables.

Potential Uses of the Results

- Develop a mathematically supported framework for predicting “reasonable” capital expenditures
  - A process will be necessary for situations not addressed by the equation
- Develop a method for measuring reasonable fiber-based broadband deployment
- Evaluate the national cost of deploying a high-capacity terrestrial broadband network